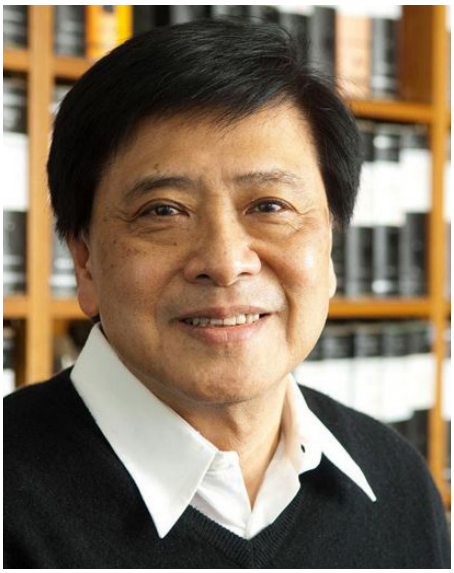
ASPB Pioneer Member

Nam-Hai Chua



I was born in Singapore one year before the Second World War ended. Owing to a vitamin deficiency, I had severe dehydration upon birth. A fortune teller advised my family - based on my zodiac signs, along with the time and date of my birth - that amongst the five elements of life (metal, wood, water, fire and earth), I was definitely deficient in water.

Accordingly, my grandfather decided to name me "Nam Hai" which in Chinese means the South Sea.

My favorite subjects in high school were mathematics and physics, and I only majored in Botany and Biochemistry at the University of Singapore out of respect for my grandfather, who had hoped that I would manage my family's rubber plantations upon graduation. During my three years in the university, I spent two summer vacations as an intern studying the distribution of members of Annonaceae and Magnoliaceae in the tropical rain forests of Malaysia and Singapore. I also did a project on Crassulacean Acid Metabolism of orchids. As a result of these early research experiences, I was fortunate enough to be awarded one of the two inaugural Fulbright fellowships given to Singapore students and started my graduate studies at Harvard University in 1965. I went to Harvard with the intention to work with Kenneth Thimann,, but he left for University of California at Santa Cruz the day I arrived in Cambridge, Massachusetts.

Consequently, I joined the lab of Paul Levine to work on the genetics of the photosynthetic electron transport chain using Chlamydomonas reinhardtii. This research paved the way for my being awarded a Maria Moors Cabot Fellowship to spend a year with Pierre Joliot at L'Institute de Biologie Physico-Chimique, Paris, France. In April 1968, I arrived in Paris to join Joliot's lab, but a nationwide student's revolution erupted one month later, rendering work in the lab difficult. Nevertheless, I got to know members of the Joliot lab, including Pierre Bennoun, with whom I subsequently established a fruitful collaboration that would play a pivotal role later in my career. I returned to Harvard in September 1968 to continue my thesis research and graduated in June 1969.

Upon my return to Singapore, I was a lecturer in the Biochemistry Department of the University of Singapore Medical School, where I taught intermediary metabolism to medical students. At the same time, I served as a part-time policeman as required by the Singapore National Service. Although I was able to do some small projects on cyanobacteria, the research infrastructure in Singapore at this time was not as developed as in the United States, and the scientific intellectual environment not as satisfying. In 1971, I left Singapore and joined the Laboratory of Cell Biology, Rockefeller University as a Research Associate, working under Philip Siekevitz and George Palade. While all the other lab members worked on the mammalian secretory pathway using predominantly the rat pancreas as a model system, I was recruited by Siekevitz and Palade specifically to pursue the biogenesis of Chlamydomonas thylakoid membranes as my main project. However, I ended up working on the isolation and characterization of cytoplasmic and chloroplast ribosomes of Chlamydomonas instead and showed that they have different sizes and sensitivity to different antibiotics. I was able to demonstrate that, in contrast to cytoplasmic ribosomes, chloroplast ribosomes are prokaryotic- like. I also showed that chloroplasts contain two populations of ribosomes, one free and the other bound to the thylakoids, presumably for synthesis and direct inser-

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tion of membrane proteins. The departure of George Palade for Yale Medical School in 1973 opened-up a number of vacancies, and I was fortunate enough to obtain an Assistant Professorship position at Rockefeller University.

In starting my own lab at Rockefeller University, our studies focused on the synthesis of chloroplast proteins. Karl Matlin joined the lab as my first graduate student. Using high resolution SDS gel electrophoresis to analyze thylakoid membranes, we identified apoproteins of chlorophyll-protein complexes. Analysis of specific photosynthetic mutants isolated by my old colleague from the Joliot lab, Pierre Bennoun, allowed us to assign thylakoid membrane polypeptides to Photosystem I or II functions. With the use of specific antibiotics, we showed that in addition to the large subunit (L) of RUBISCO (Ribulose bisphosphate carboxylase), a number of thylakoid membrane polypeptides were synthesized inside the organelle and presumably encoded by the chloroplast genome. In support of this, some of these polypeptides were subsequently shown to be encoded by genes that follow uniparental transmission.

However, our observation that most chloroplast proteins are made in the cytosol raised the interesting question of how they are imported into the chloroplasts. In collaboration with Bernhard Dobberstein, a post-doctoral fellow with Gunter Blobel at Rockefeller, we showed that the small subunit (S) of RUBISCO was synthesized as a precursor (pS) about 4-5 kd larger than S. Together with Greg Schmidt, the first postdoctoral fellow in our lab, we showed that pS can be imported into intact chloroplasts after translation and processed into S which then assembled with the endogenous L to form the holoenzyme. Sequence analysis showed that the pS contains an extra sequence of 44 amino acids which we termed the "transit peptide" for chloroplast import. Subsequently, we showed that most chloroplast proteins are made as precursors and imported into the organelle by an energy-dependent reaction.

The work on the RUBISCO small subunit prompted my lab at Rockefeller to investigate cDNA and genomic sequences of nuclear DNA encoding major chloroplast proteins. With the availability of transgenic technology, we started to explore mechanisms governing light- regulation of photosynthetic genes, their organ-specific expression and nuclear factors that bind to upstream elements of these genes. Subsequently, our research interest also extended to the characterization of the Cauliflower Mosaic Virus 35S promoter and interacting nuclear factors and to genes responsive to the drought hormone, abscisic acid (ABA).

For the last two decades, a major part of our lab's effort was dedicated to investigations of post-translational regulation of transcription factors involved in light, auxin and ABA response pathways. We have also worked on miRNAs and long noncoding RNAs and elucidated their mechanisms of action in biotic and abiotic stresses.

Much of what we do in plant biology and biotechnology is driven by advances in new technology and the advent of new tools. In this regard, we are pleased that the 35S promoter was used to express trait genes in the first generation of transgenic crops plants. This promoter is also preferred by most investigators of plant biology when a strong, constitutive expression of a target gene is needed. We have also designed two synthetic inducible expression systems (GVG and XVE) which provide excellent controlled expression of target genes, and they are used frequently by the Plant Biology community.

Following my transition to Andrew W. Mellon Professor Emeritus, Rockefeller University, in September 2018, I continued my research projects at the Temasek Life Sciences Laboratory, National University of Singapore. I had spent almost forty-seven years at Rockefeller University. The Rockefeller University is really an unparalleled place to do research and it is very difficult to explain the unique opportunity it offers unless you have experienced it. I am extremely grateful to the university for providing generous lab space and ample resources which allowed our research to flourish. Over the years our work was supported in part by NIH and DOE, and for

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this I am thankful. We have also benefited from our collaborations with several companies including Monsanto, DuPont, Zeneca, Gendaq, Sumitomo Chemical, Bayer and KWS.

In 1998, Bob Goldberg made the important and insightful decision to start a new journal called the Plant Cell under the sponsorship of ASPB. I was recruited by Bob to serve on the founding Editorial Board for four years. During this period, I was impressed with Bob's insistence for high quality and standard, and not surprisingly, the journal has evolved into one of the top journals in Plant Biology. In 2010, the ASPB conferred upon me the Lawrence Bogorad award for Excellence in Plant Biology Research, for which I feel humbled and honored.

In reflecting over my academic research career of about five decades I have come to subscribe to the view of Newton: "If we see farther, it is because we stand on the shoulders of giants". Scientific inquiry is very much a collective effort, and ideas breed ideas. Quite often credit is disproportionately assigned to a Principal Investigator when many others in the lab have contributed significantly. I take this opportunity to express my gratitude and appreciation to generations of students, post-doctoral fellows, research associates and visiting professors who have contributed much to our shared research objectives. The success of our research owes much to their unceasing dedication, excellent scientific intellect and superb technical skills. I am delighted that many of them have gone on to become giants in Plant Biology. They have also become good friends. I had learned much from them as they had from the lab, and to all these alumni I owe a big "Thank You".

Returning to my name, South Sea, I believe that this name predisposed me to pursue scientific research which - like the sea itself - is vast and limitless.

Like all explorers, I set out on my lifelong pursuit of scientific study without knowledge of my end destination, but with an openness to the journey. The unchartered voyage has taken me to the shores of many new frontiers. For young aspiring plant biologists who are starting out their career, there is nothing more appropriate than the words of Steve Jobs: "Stay hungry, stay foolish". In this new world of exploding knowledge, always staying open to learning more and changing directions as necessary are the two keys to success. Don't worry too much about the destination; just enjoy the voyage. Bon Voyage!

Academic Family Tree: Nam-Hai Chua **https://academictree.org/plantbio/tree.php?pid=70101**